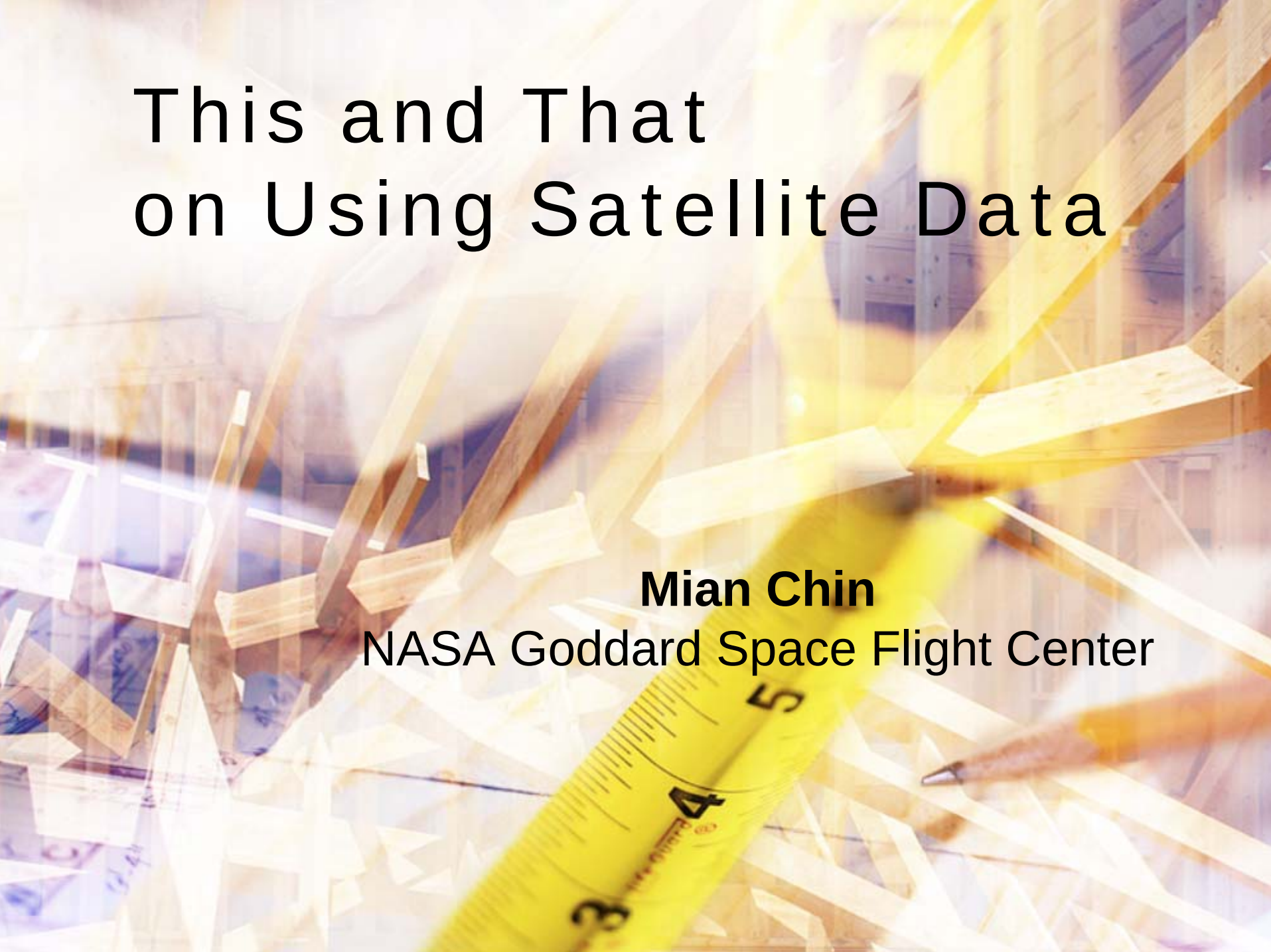
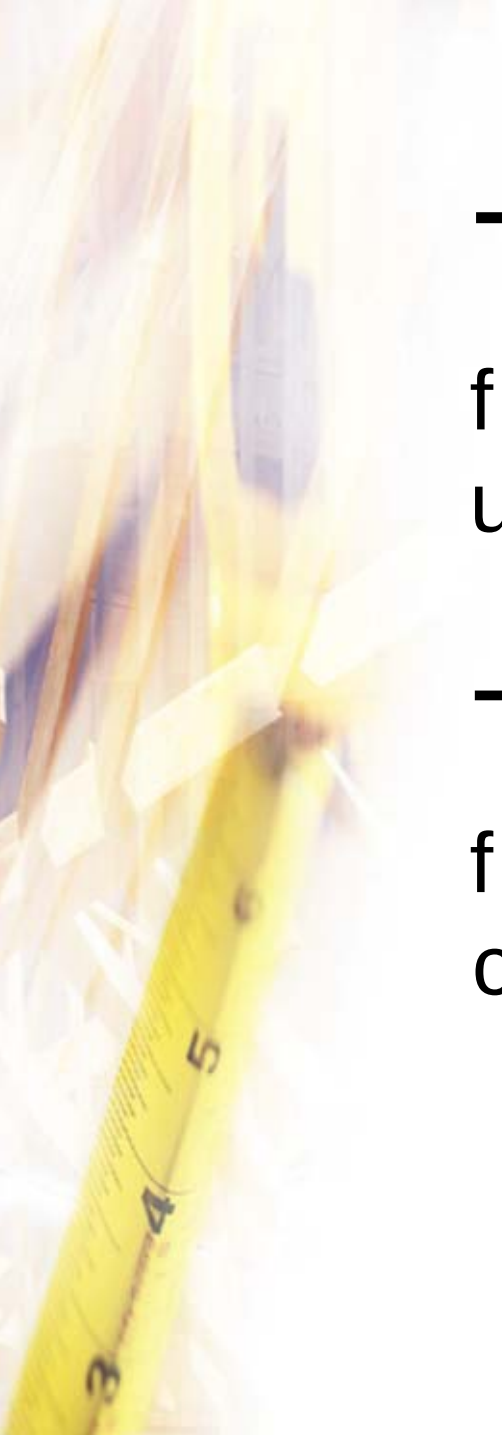
This and That on Using Satellite Data



Mian Chin
NASA Goddard Space Flight Center



This: Using satellite data for global model evaluation – uncertainties

That: Using satellite data for monitoring air quality – challenges

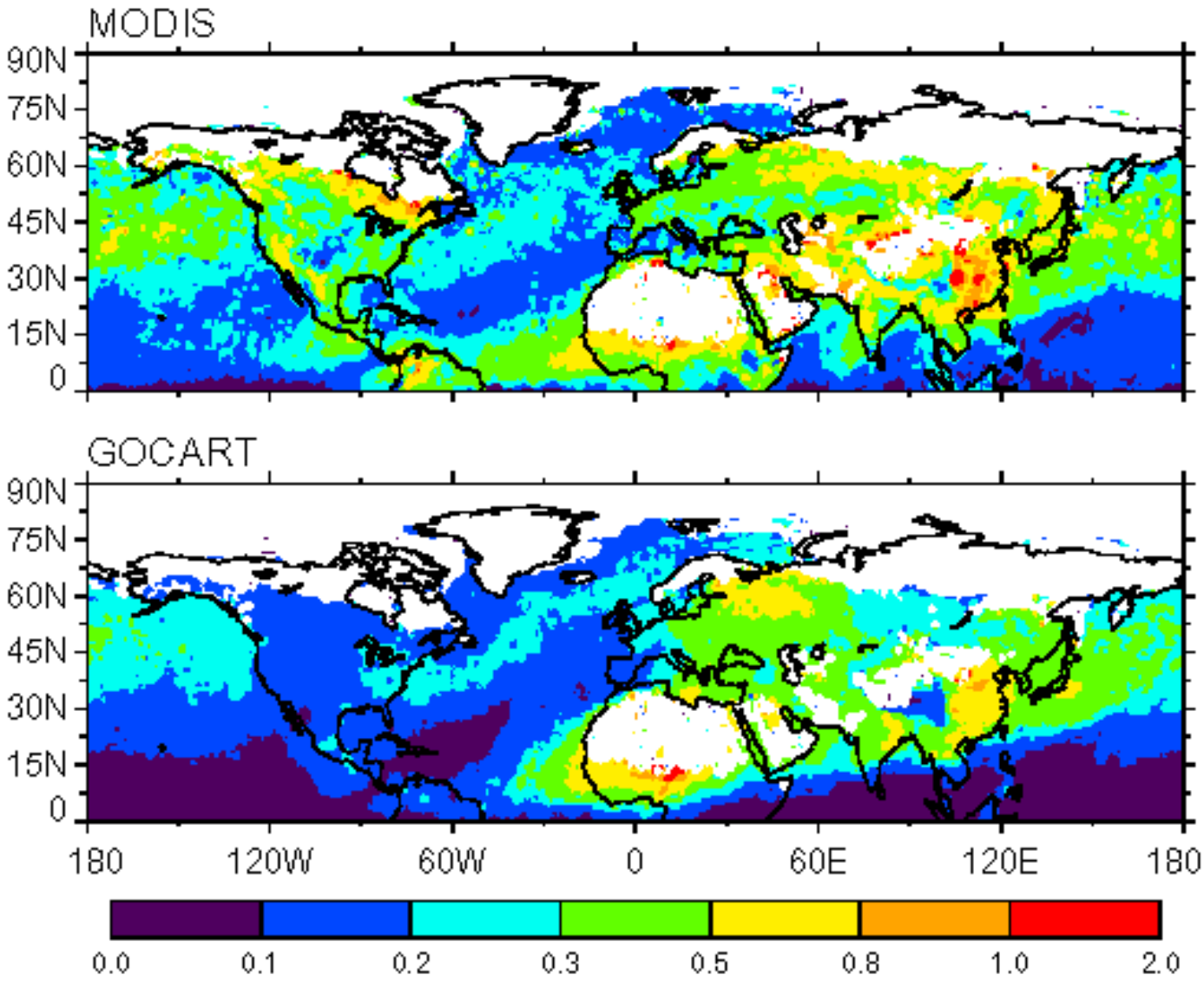
Aerosol Distribution in the NH During ACE-Asia: Results from GOCART, MODIS, AERONET

- ACE-Asia: Field intensive in spring 2001 over western Pacific
- Aircraft, ship, and surface measurements provided detailed aerosol concentration and properties over the Asian-Pacific area
- Satellite data provided large-scale aerosol distributions and transport
- A global model can synthesize this wide array of data for quantitative analysis and assessment

Model and Data

- GOCART (model):
  - Global, 2 latitude x 2.5 longitude, 30 vertical layers
  - Using GEOS-DAS assimilated meteorology (GEOS-3 in 2001)
  - Simulates sulfate, dust, BC, OC, and sea-salt mass and AOT
  - We use model output of daily (24-hour) average under all sky (cloudy and clear) conditions
- MODIS (satellite retrieval):
  - Level 3 (gridded 1x1), version 4 (quality assured)
  - Products used: AOT at 550 nm and fine mode fraction, over both land and ocean
  - Cloud-free data, local overpass at 10:30 am

Distributions of AOT in 200104

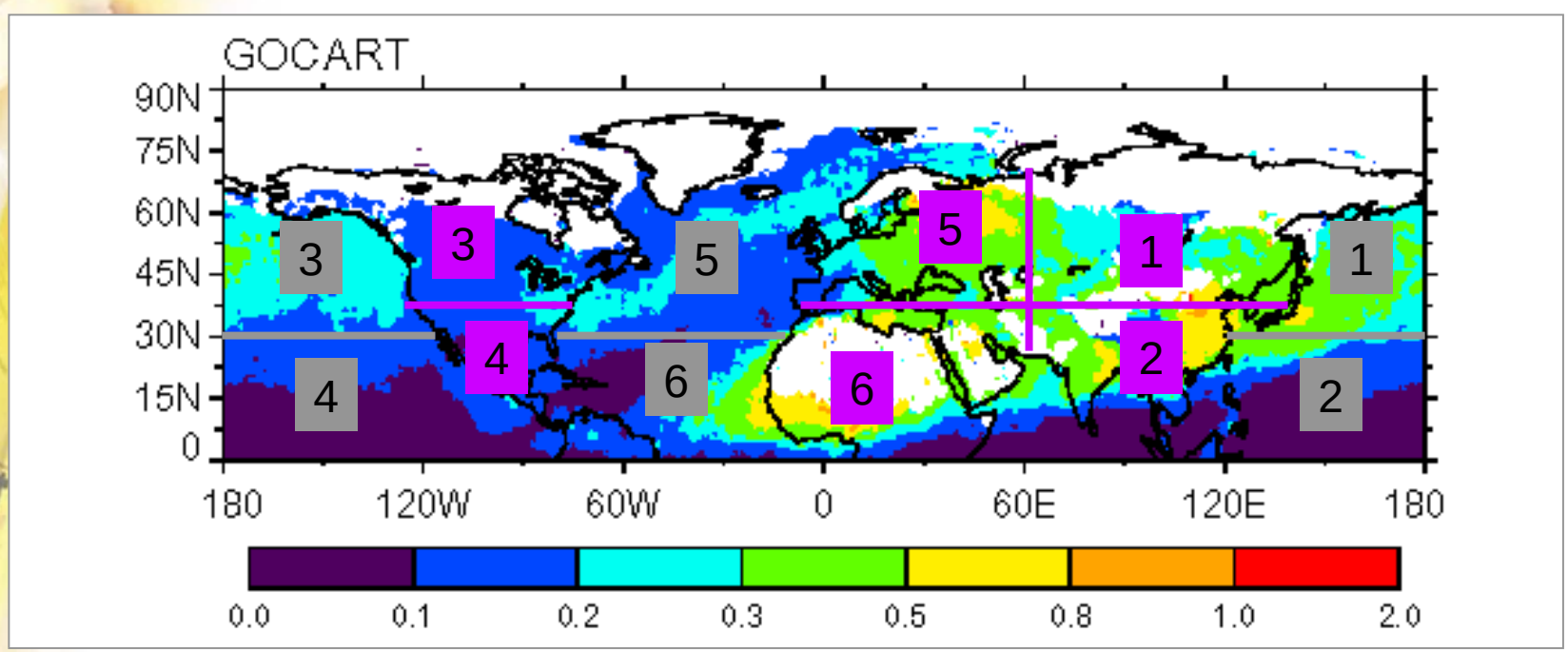


Distributions of AOT in 200104

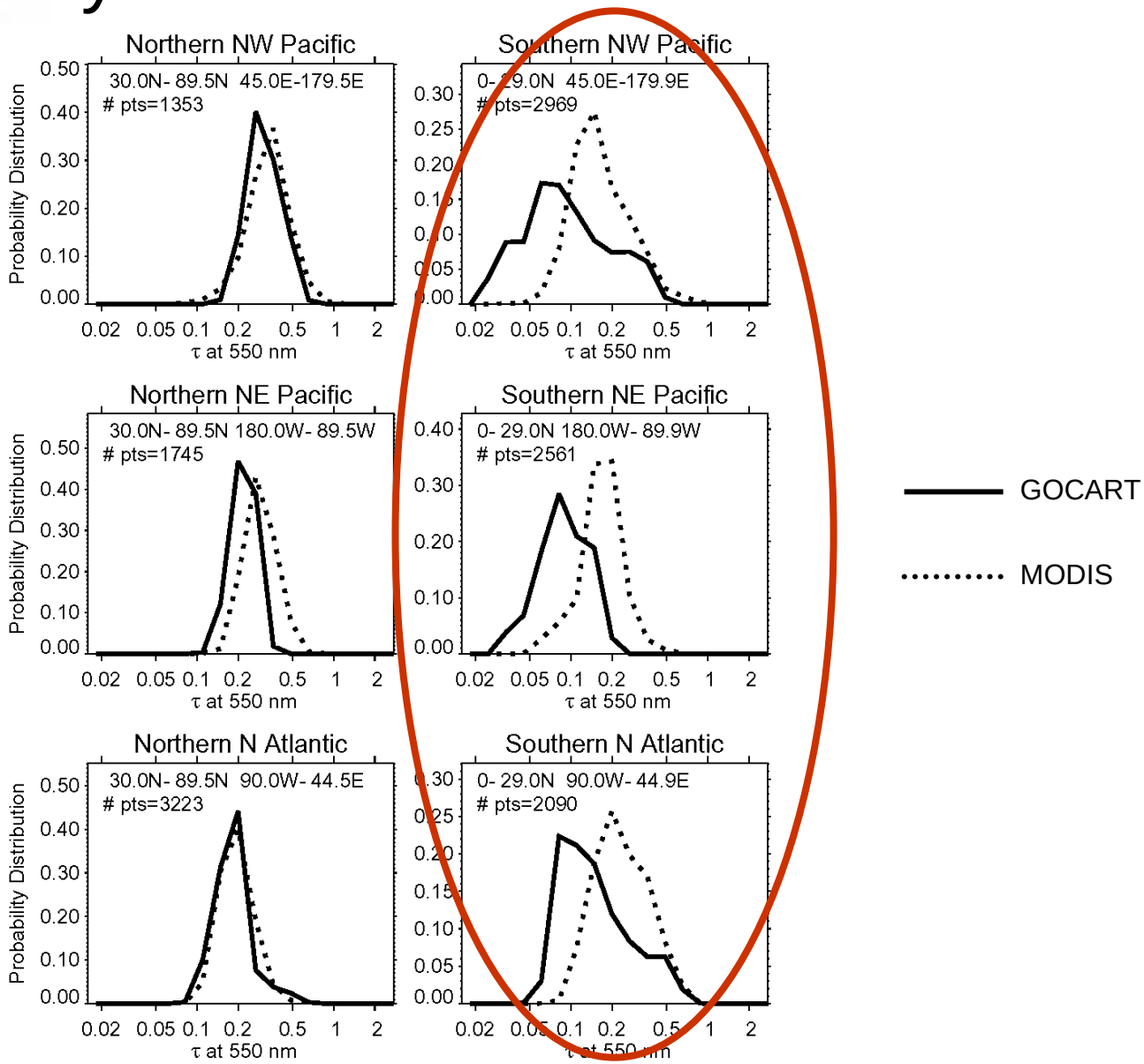
We divide the N.H. into 6 oceanic and 6 land regions:

1. N NW Pacifc
2. S NW Pacifc
3. N NE Pacific
4. S NE Pacific
5. N North Atlantic
6. S North Atlantic

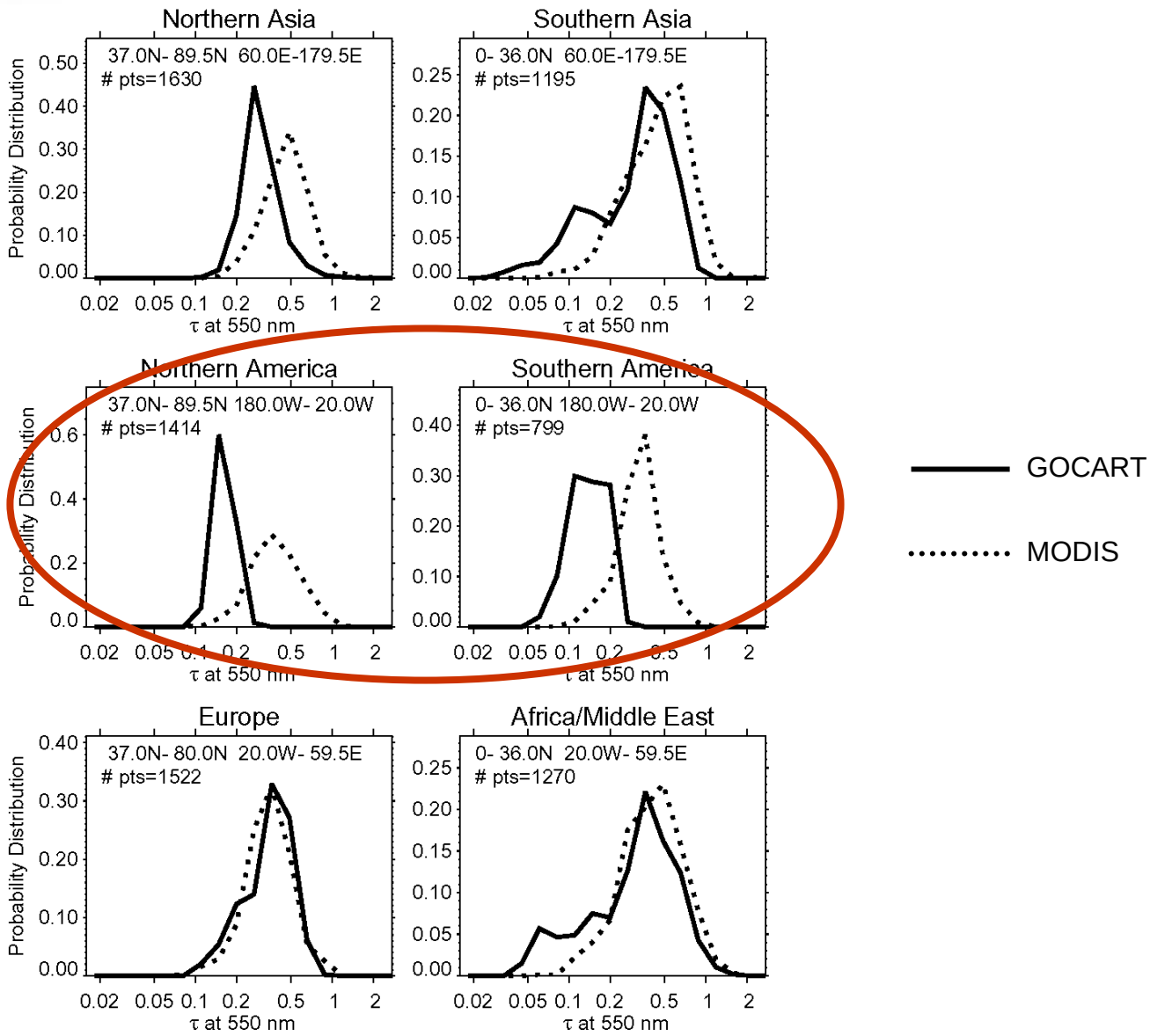
1. N Asia
2. S Asia
3. N America
4. S America
5. Europe
6. Arica/Middle East



Probability distributions – Over ocean



Probability distributions – Over land



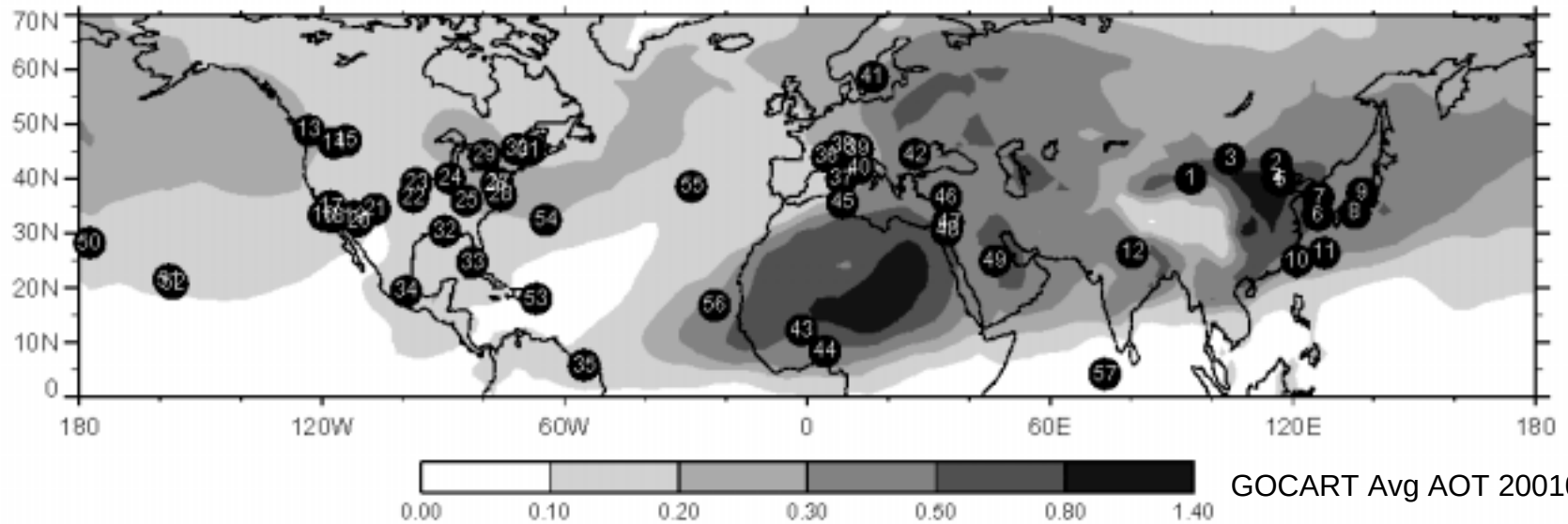
Major regional differences between the GOCART and MODIS are –

- Over North/central America
- Over tropical/subtropical oceans

Should we believe that the MODIS is more right than the model?

Comparisons with AERONET

AERONET Sites



GOCART Avg AOT 200104

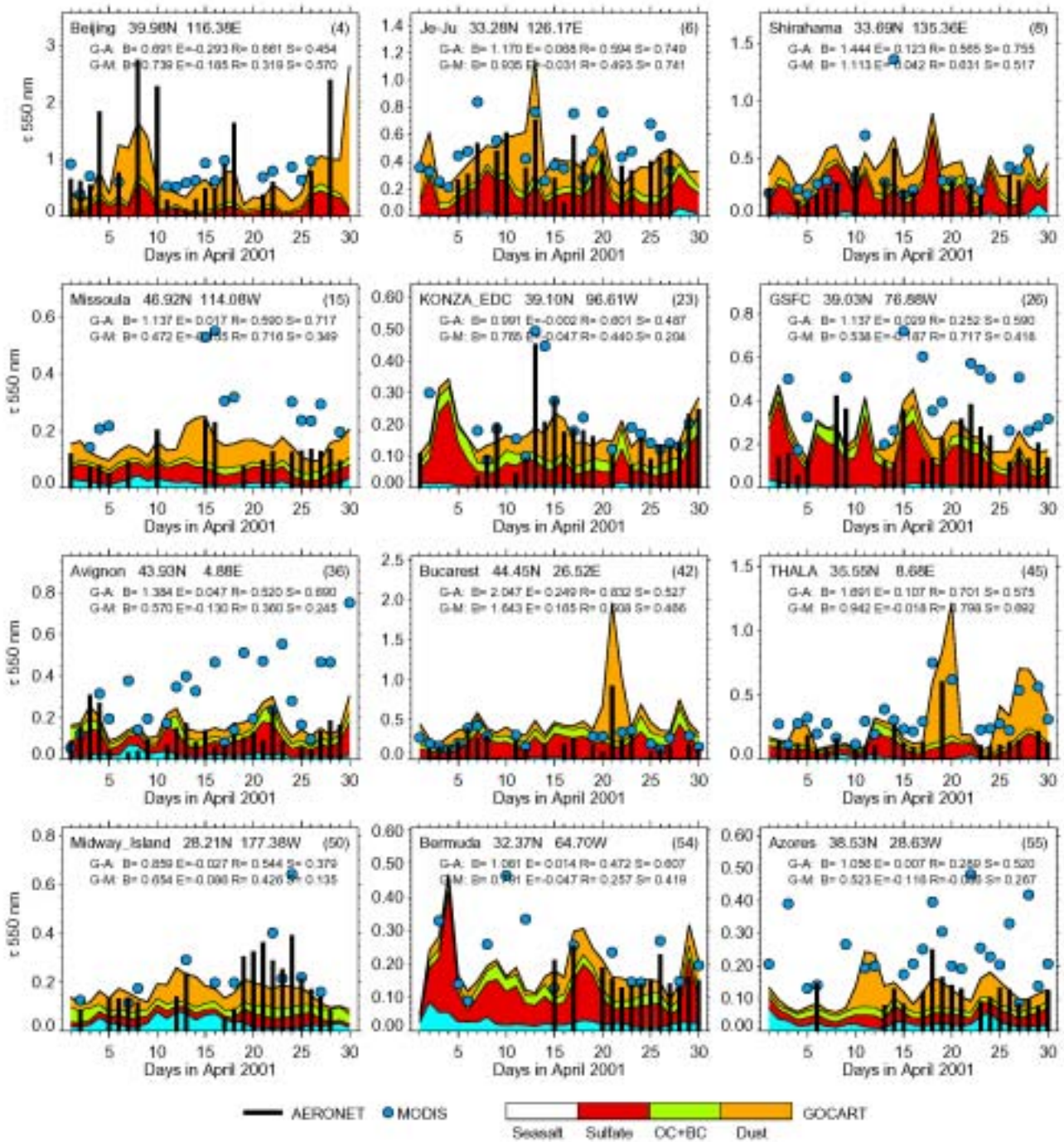
- **Sites 1-12: Asia**
- **Sites 13-35: North America and Surinam (South America)**
- **Sites 36-49: Europe, Africa, Middle East**
- **Sites 50-57: Oceans**

Asia

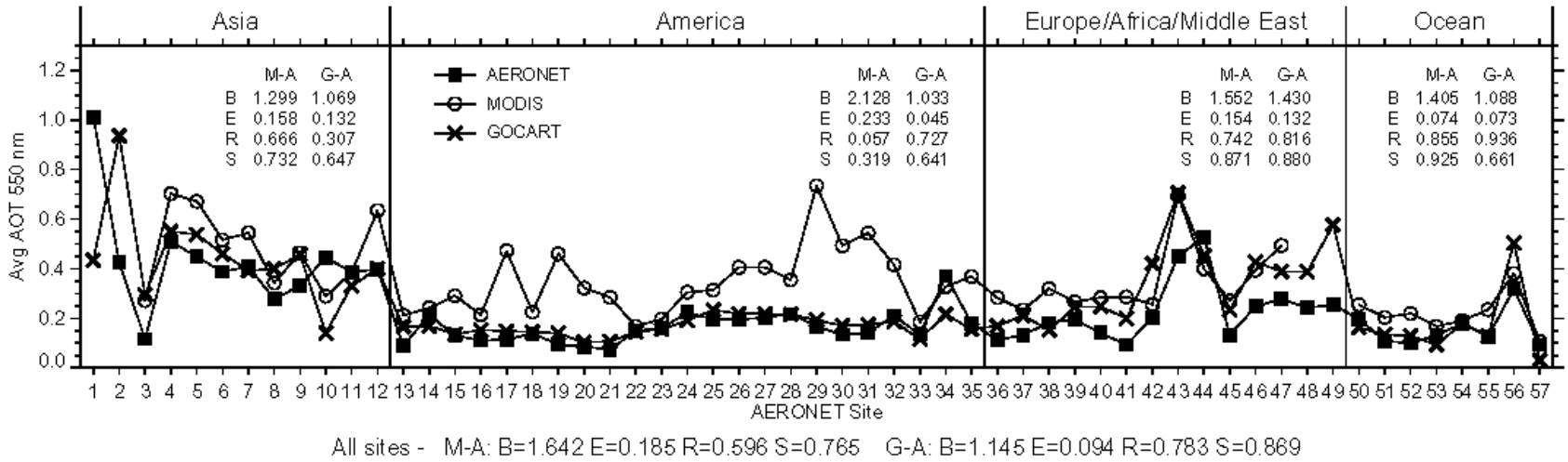
North America

Europe/ Africa

Oceans



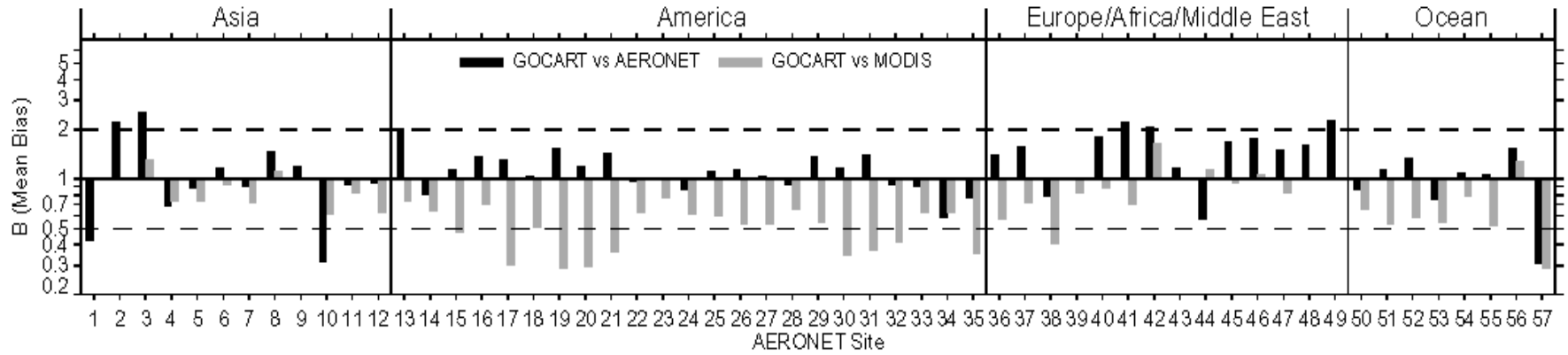
Average AOT



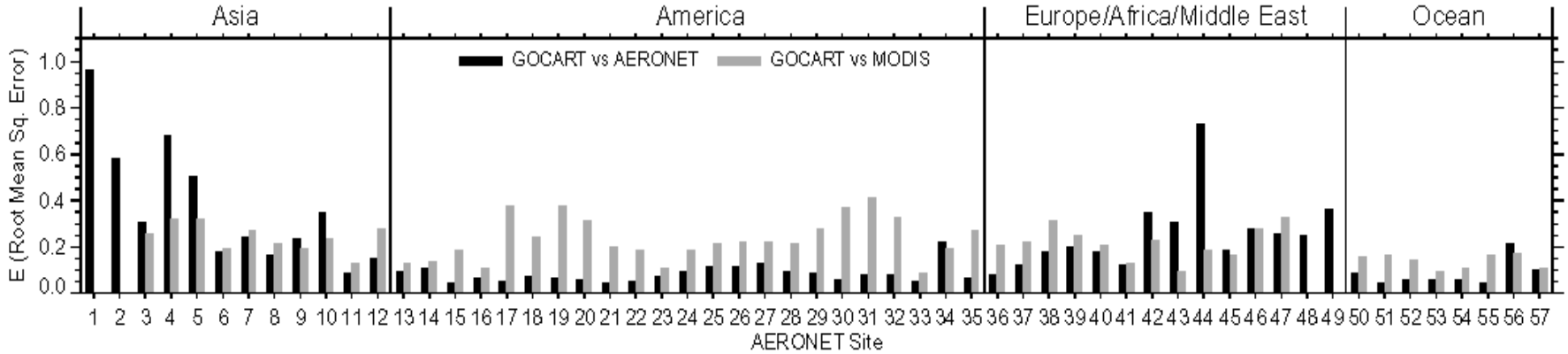
All sites - M-A: B=1.642 E=0.185 R=0.596 S=0.765 G-A: B=1.145 E=0.094 R=0.783 S=0.869

B (mean bias) and E (RMSE)

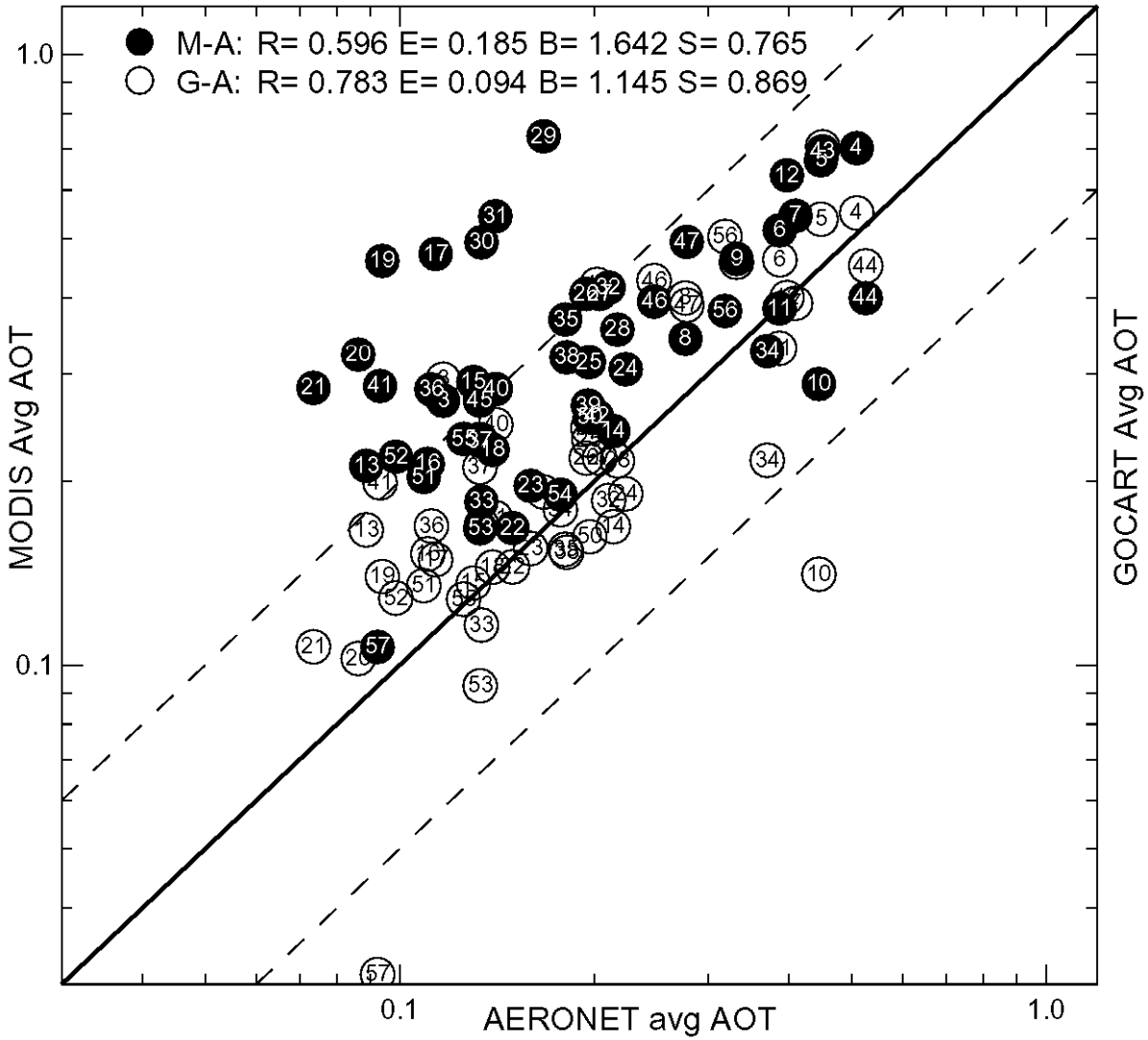
B



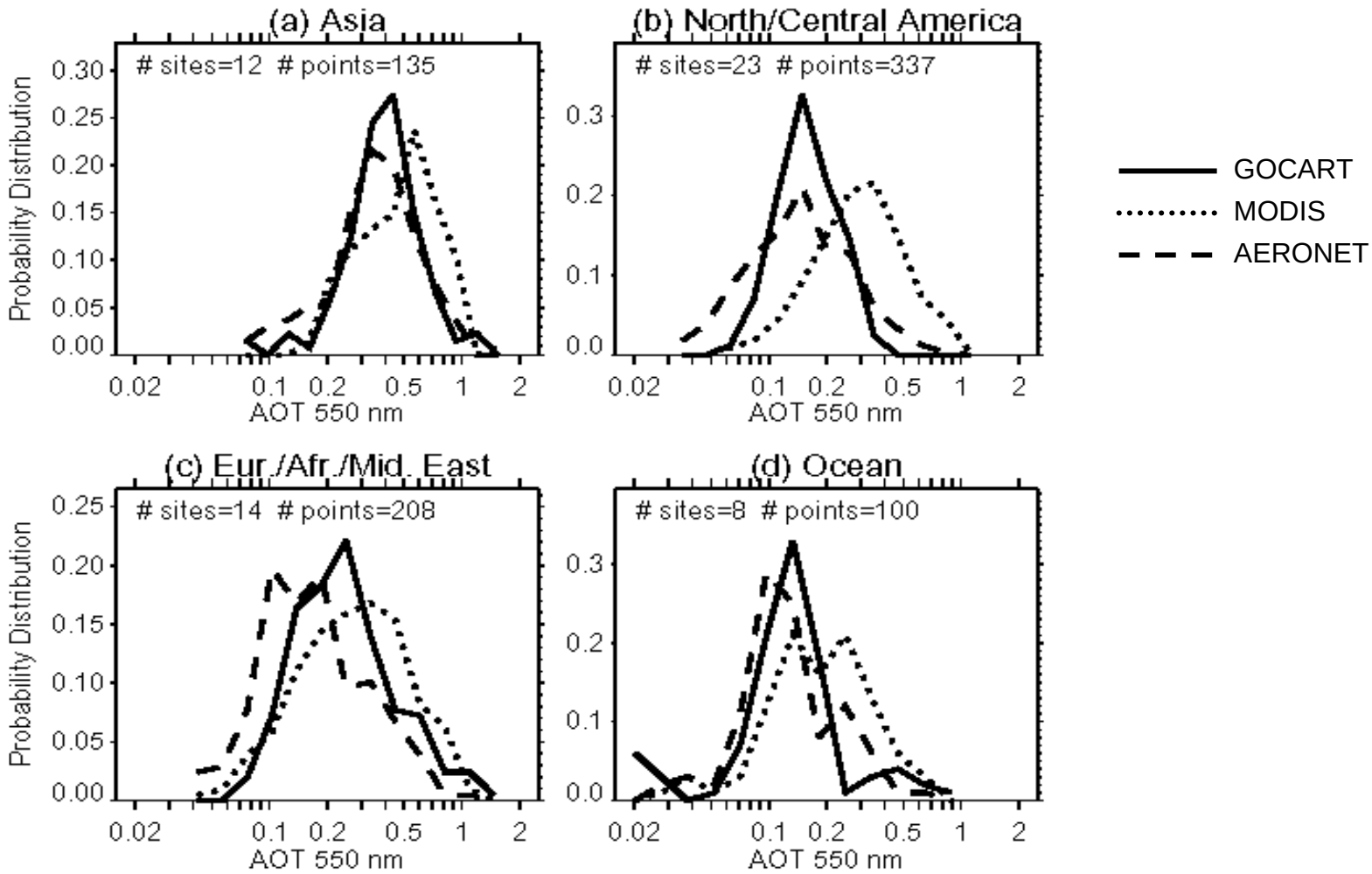
E



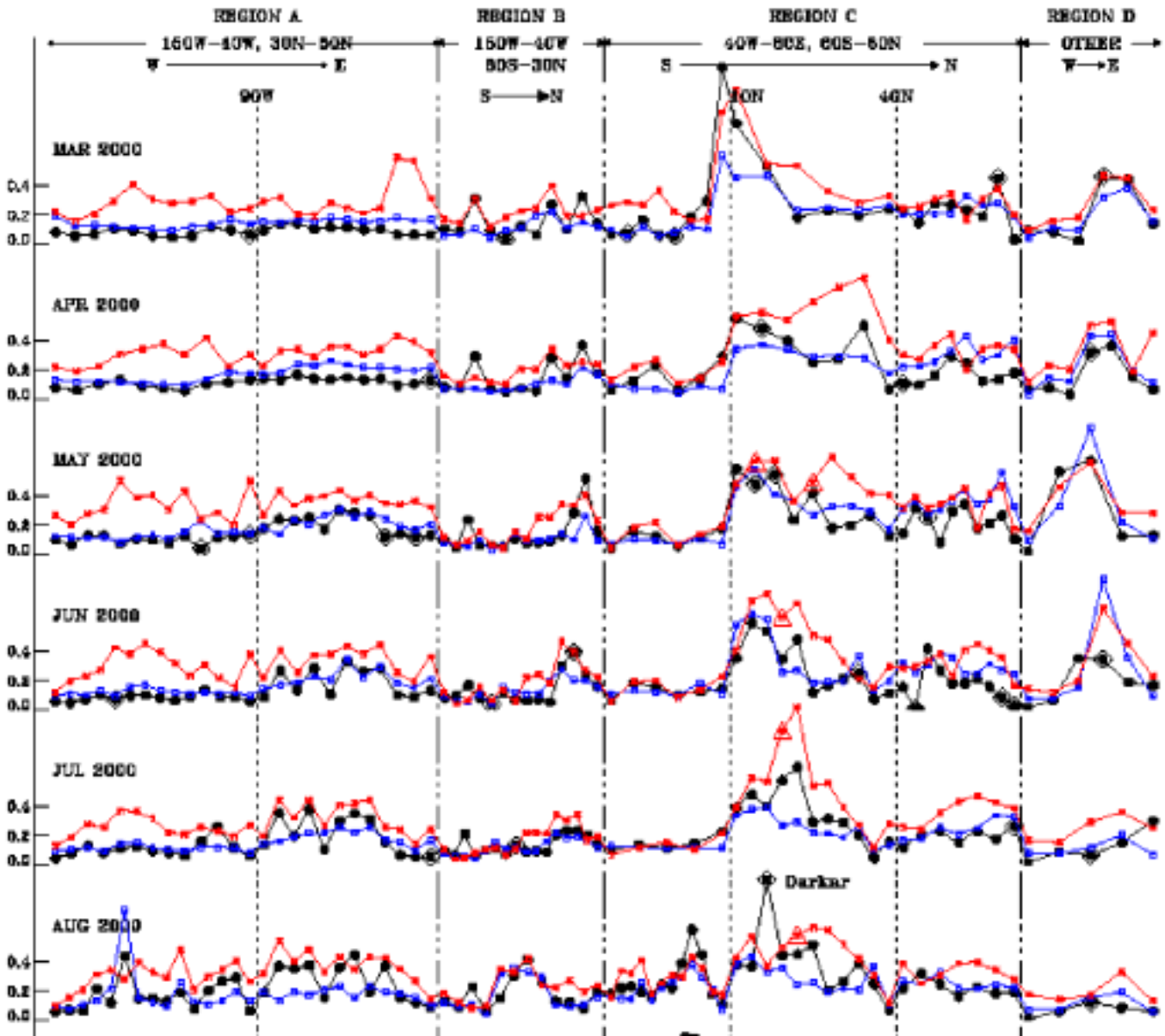
Scatter plot



Probability distributions



← N. America → ← S. Am → ← Africa → ← Eur → ← Asia →

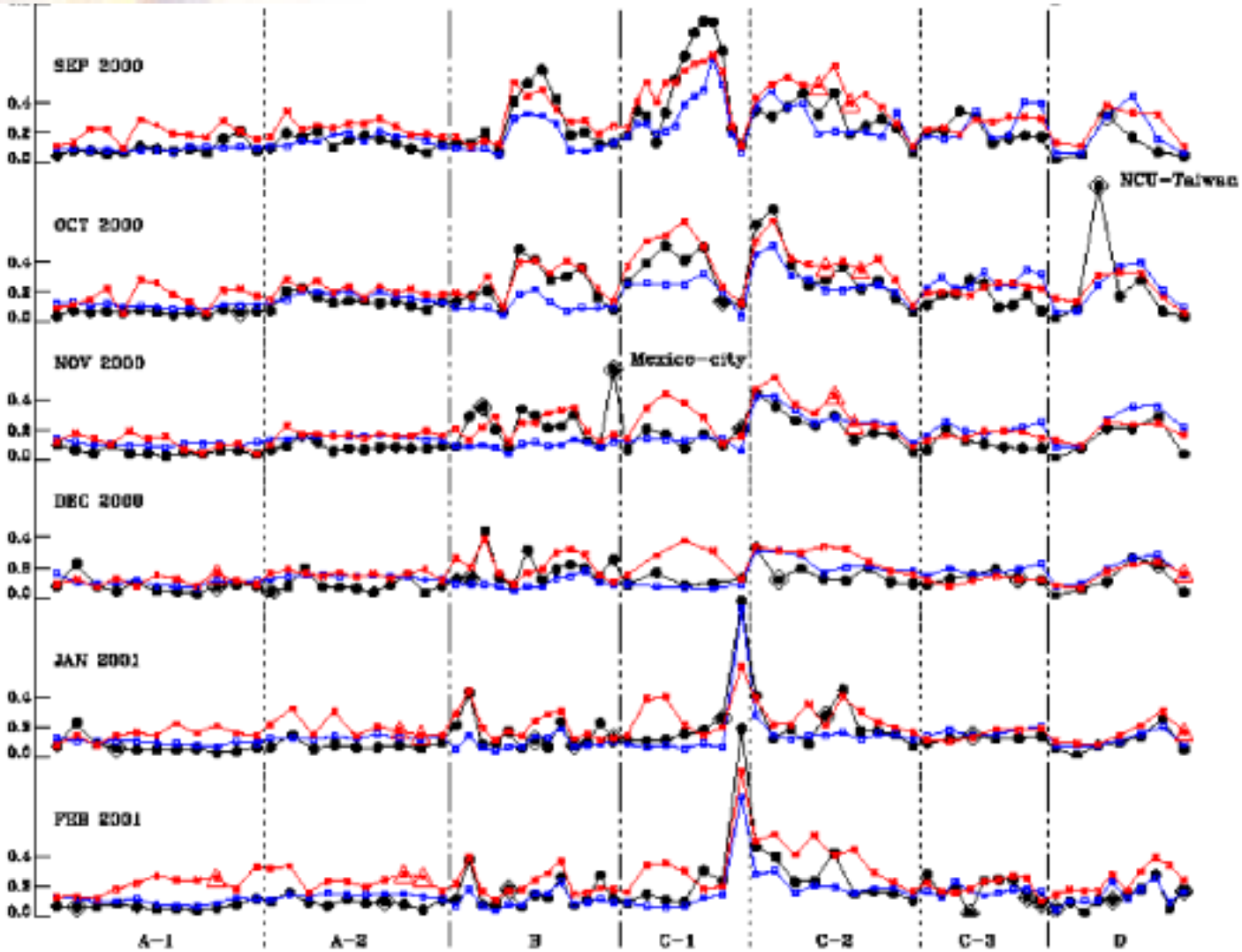


Comparisons at global sites

From:
Liu, Pinker, Holben
Submitted to JGR

GOCART
MODIS
AERONET

← N. America → ← S. Am → ← Africa → ← Eur → ← Asia →



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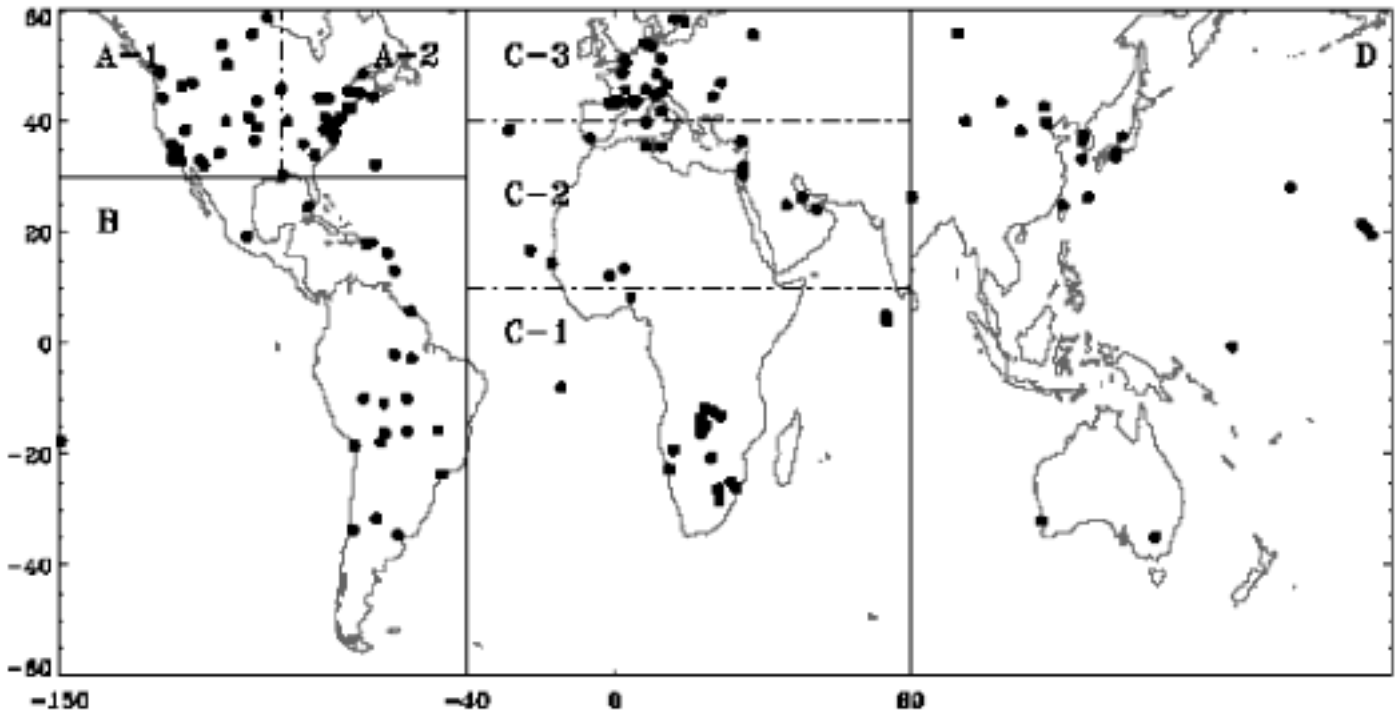

A-1
A-2
B
C-3
C-2
C-1
D
60
40
20
0
-20
-40
-60
-150
-40
0
60

Summary of “This”:

- The largest discrepancies between the MODIS and GOCART AOT in April 2001 are in North America and the tropical oceans
- It seems that MODIS is biased high in North America especially in the SW and NE regions due to the surface reflectance
- Model may have problems in the tropical oceans, but more direct measurements are needed to verify
- AERONET – serves as “truth”. It should be included in aerosol “assimilation” or “integration” processes as internal calibrations for quality control

Using satellite data for monitoring air quality

- MODIS aerosol optical thickness often tracks the change of surface PM2.5 concentrations

12 Sept. 2002-The high AOD from MODIS is seen stretching along the entire Gulf Coast and extending out into the Atlantic Ocean. This transport was caused by T.S. Gustav pulling off into the North Atlantic and the development of T.S. Hanna in the Gulf.

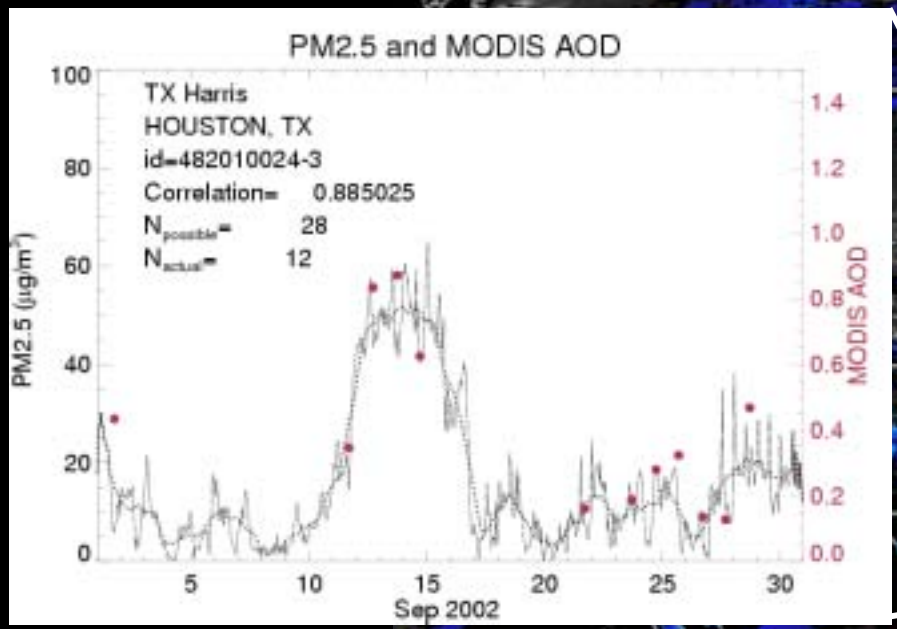


Figure from Allen Chu, Jim Szykman, Brad Pierce

AQI > 100

0.0 0.2 0.4 0.6 0.8 1.0 | 0 10 20 30 40 50 60 70 | 0 15.5 40.5 65.5 150.5

NASA/EPA Aerosol Optical Depth | Cloud Optical Thickness | PM2.5 (ug/m3)

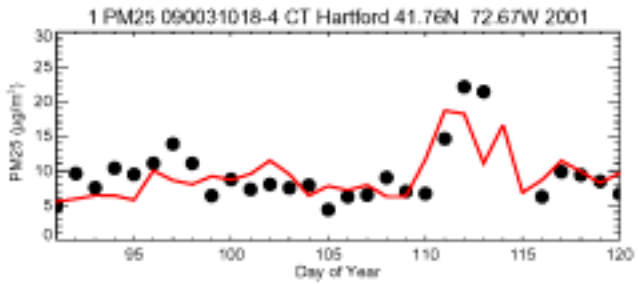
Can we quantitatively use the satellite AOT to predict surface PM2.5?

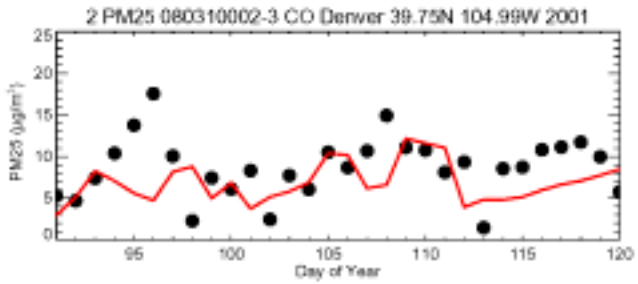
- Possible – since the major aerosol source over the US is the anthropogenic emission at the surface
- Difficult – since aerosol composition and distribution have large spatial and temporal variations due to emission, transport, and removal processes such that the relationship between AOT and PM2.5 have large spatial and temporal variations

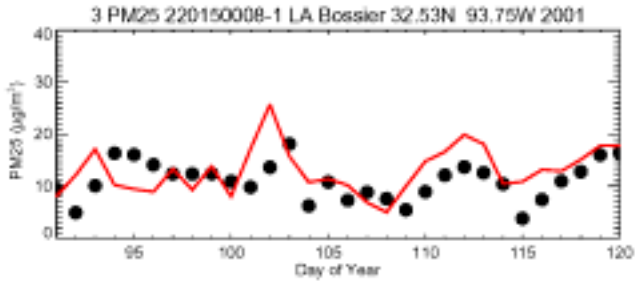
GOCART vs EPA PM2.5
Symbol: data Line: model

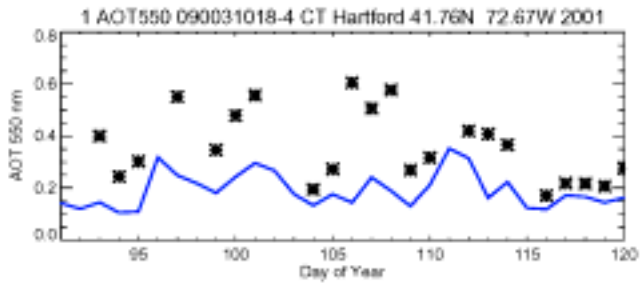
GOCART vs MODIS AOT
Symbol: data Line: model

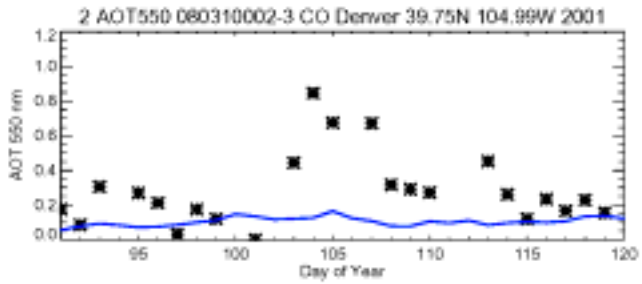
PM2.5

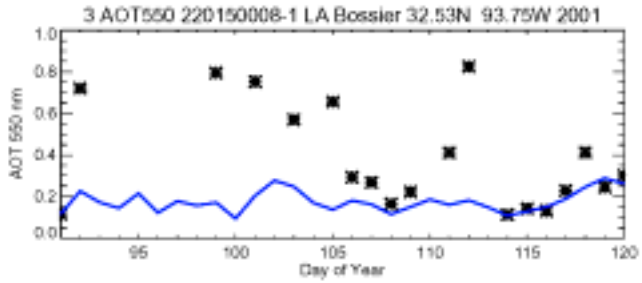












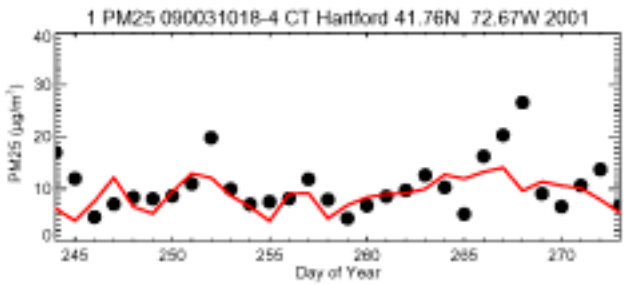
AOT

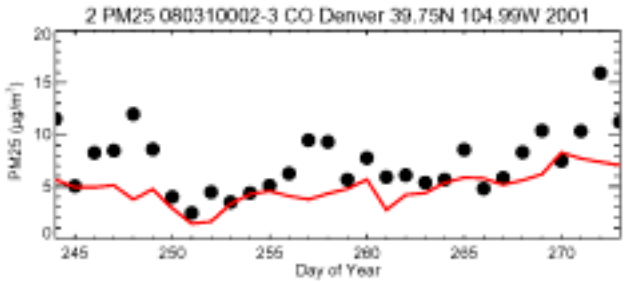
April 2001

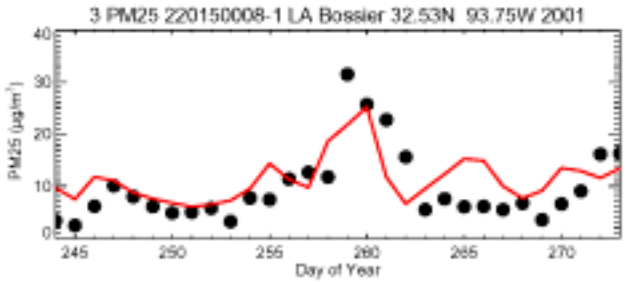
GOCART vs EPA PM2.5
Symbol: data Line: model

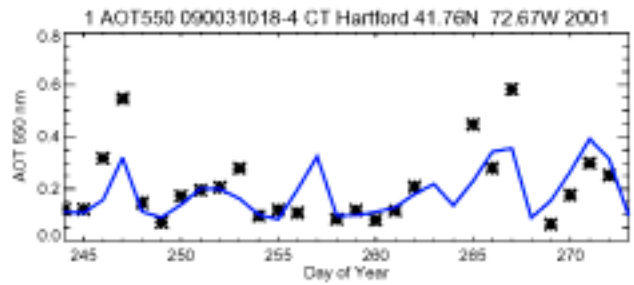
GOCART vs MODIS AOT
Symbol: data Line: model

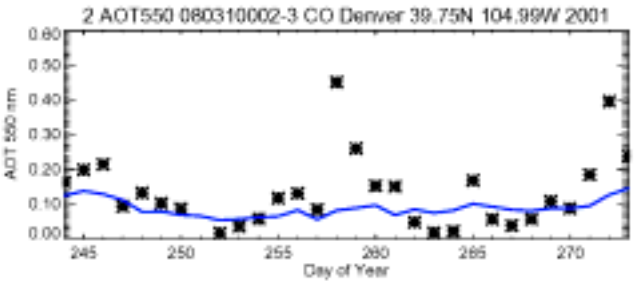
PM2.5

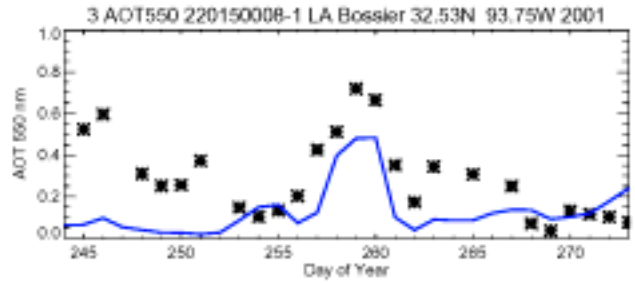








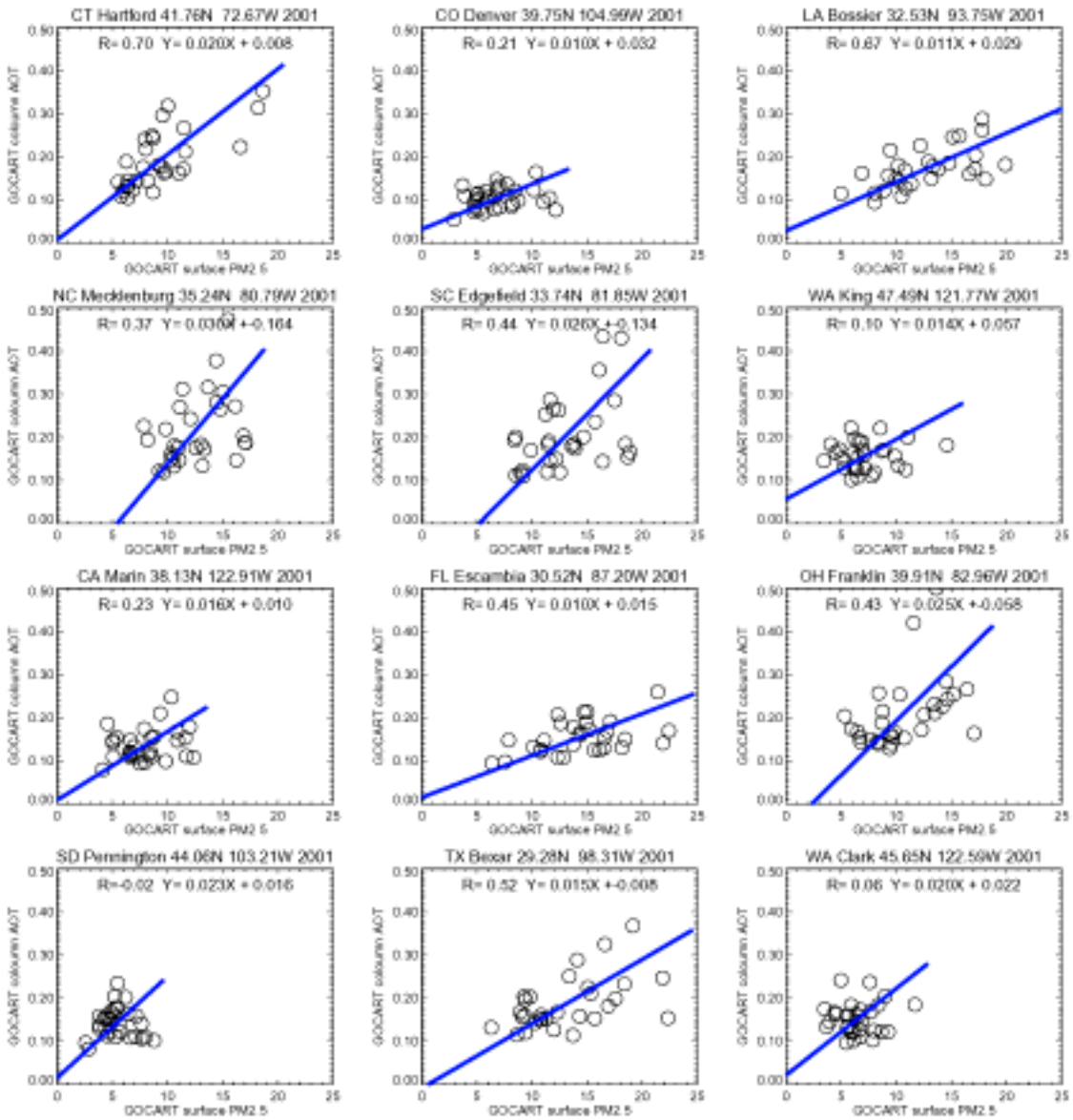




AOT

September 2001

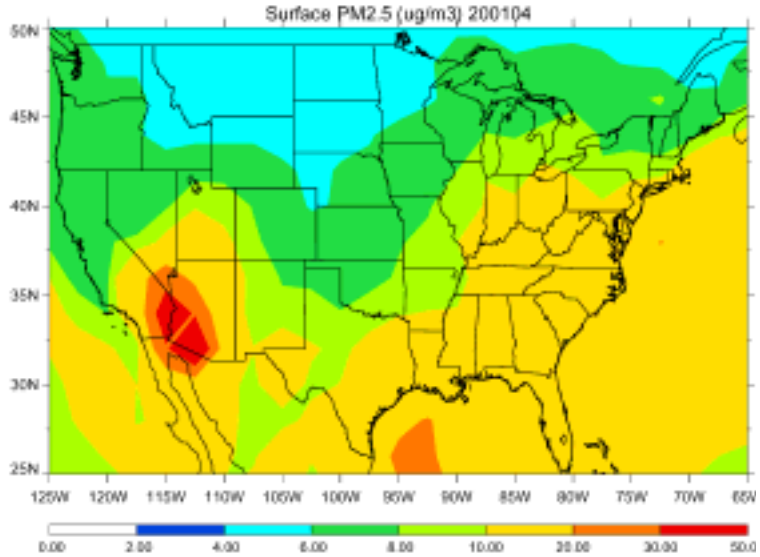
Relationship between AOD and PM2.5 in GOCART model 200104

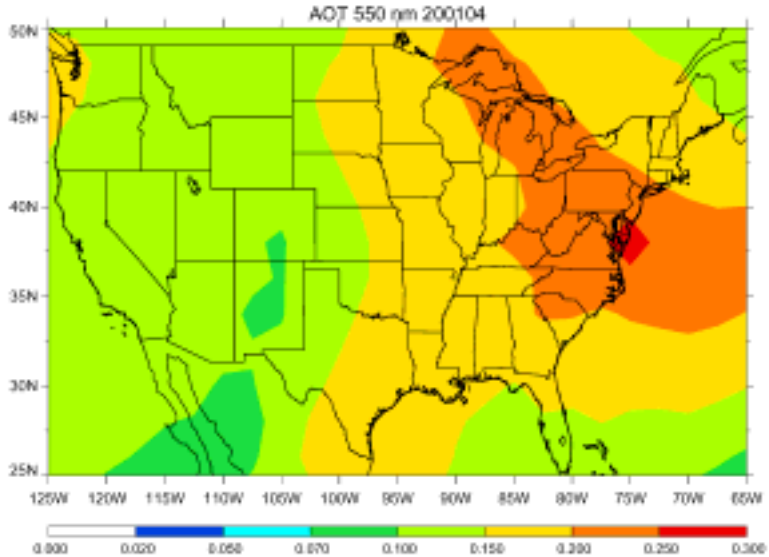


PM2.5

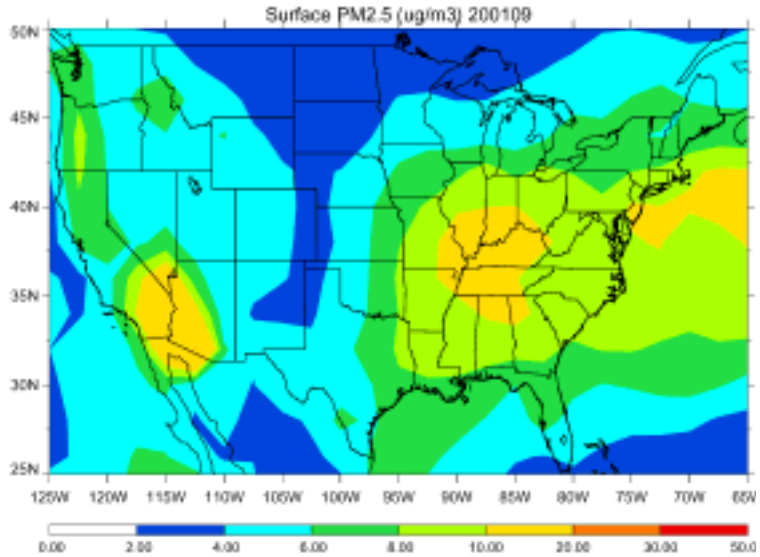
AOT

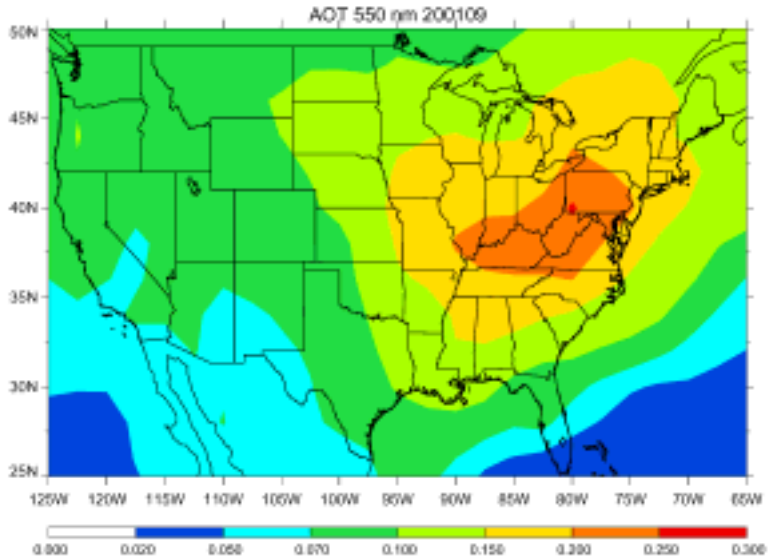
April





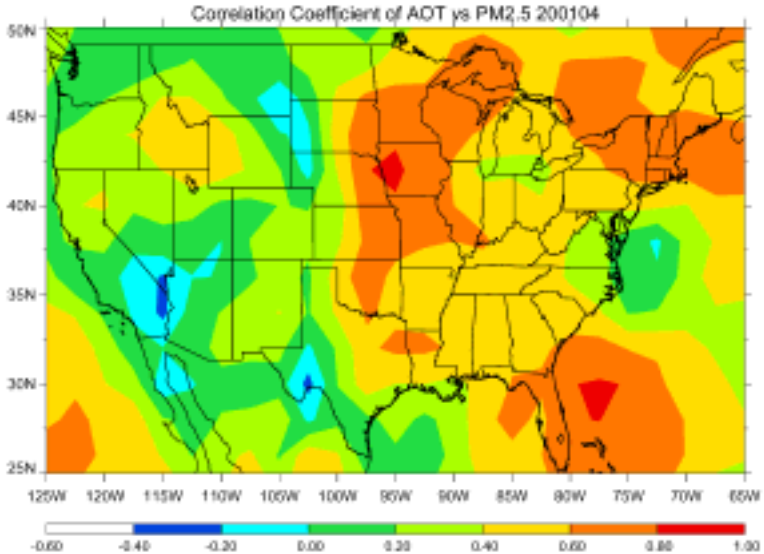
September



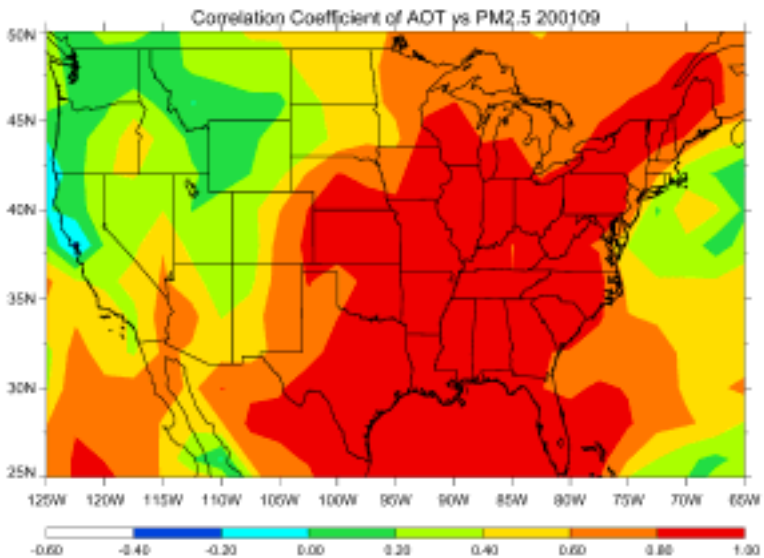


Correlation Coefficient between AOT and PM2.5

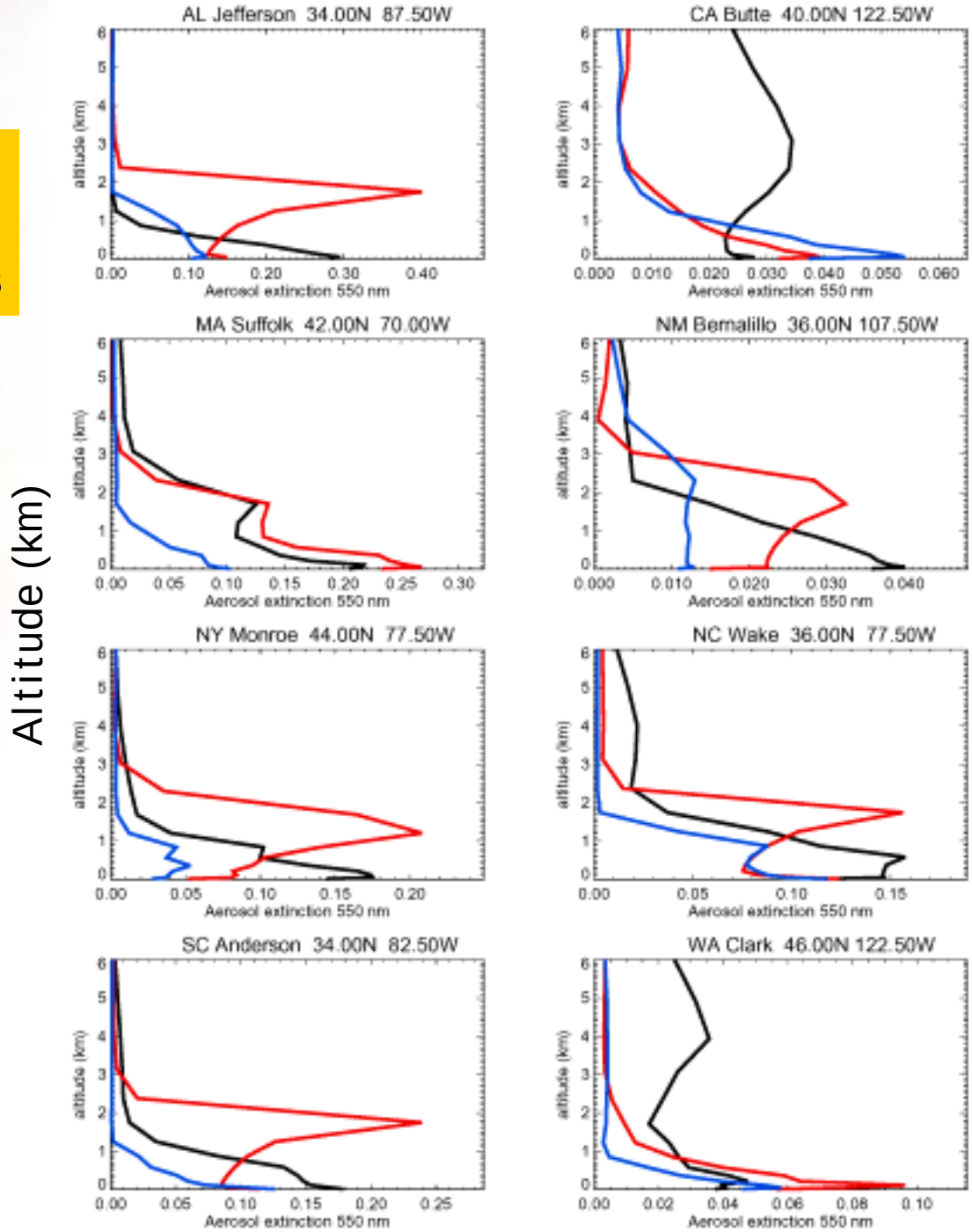
April



September



Aerosol Vertical Distributions



April
July
September

Comments of "That"

- There is no simple quantitative relationship between column AOT and surface PM2.5 because the aerosol composition and vertical profiles change with geographic locations and time
- Satellite data can provide useful guidance for PM2.5 forecast, but quantitative use is difficult
- In addition, satellite data are not always available mainly due to the presence of clouds